



# ***Annotated Briefing on the DoD High Level Architecture for Simulation***

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# Outline

- **Introduction/Overview**
- **High Level Architecture**
- **Prototyping**
- **Interoperability and Reuse**
- **Compliance and Supporting Standards**



## DoD M&S Master Plan Objective 1-1

- **Objective 1-1. Establish a common high-level simulation architecture to facilitate the interoperability of all types of models and simulations among themselves and with C4I systems, as well as to facilitate the reuse of M&S components.**
  - Simulations developed for particular DoD Components or Functional Areas must conform to the High Level Architecture
  - Further definition and detailed implementation of specific simulation system architectures remain the responsibility of the developing Component

***The Common Technical Framework, and specifically the High Level Architecture, represents the highest priority effort within the DoD modeling and simulation community.***

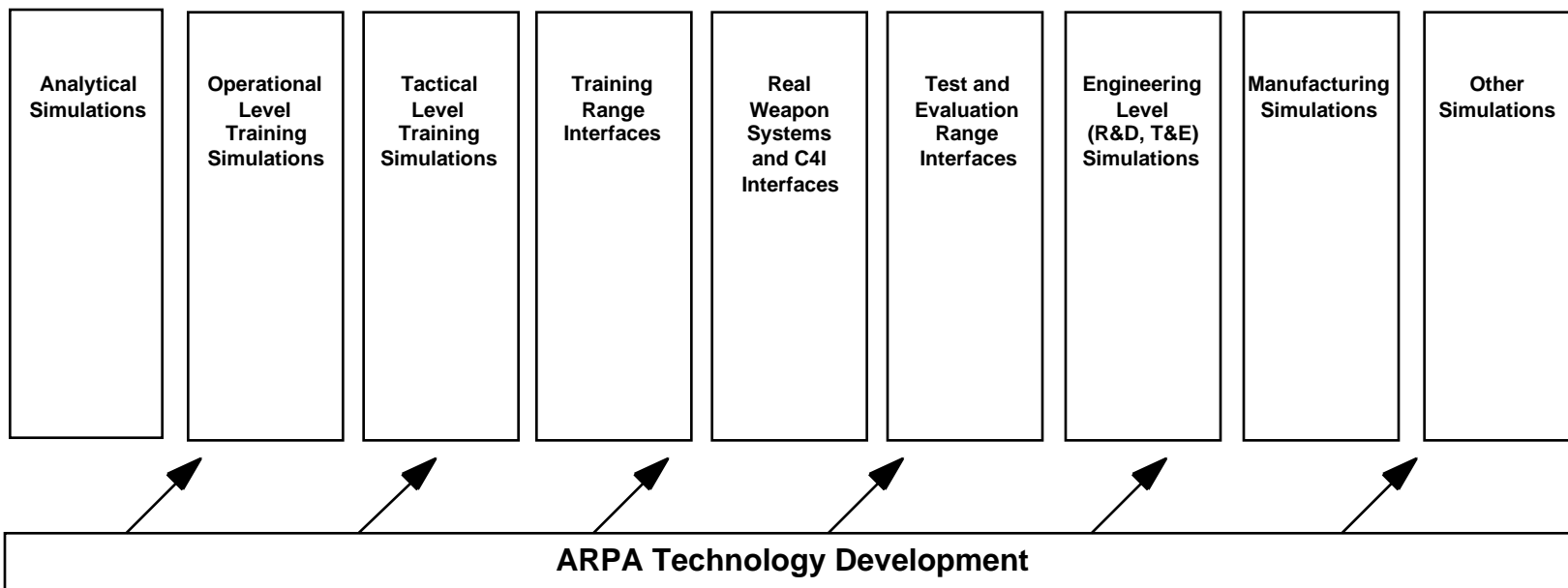


# An Overarching Technical Framework

## Master Plan's Technical Framework

High Level Architecture, Conceptual Models Of the Mission Space, Data Standardization

### Domain-specific aspects





# High Level Architecture

**Major functional elements, interfaces, and design rules, pertaining as feasible to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined**



# Scope of HLA

- **Applicable to broad range of functional areas (e.g., training, contingency planning, analysis, and acquisition)**
- **Applicable to simulations involving pure software representations, man-in-the-loop simulators, and interfaces to live components (e.g., instrumented-weapon systems and C3 systems)**

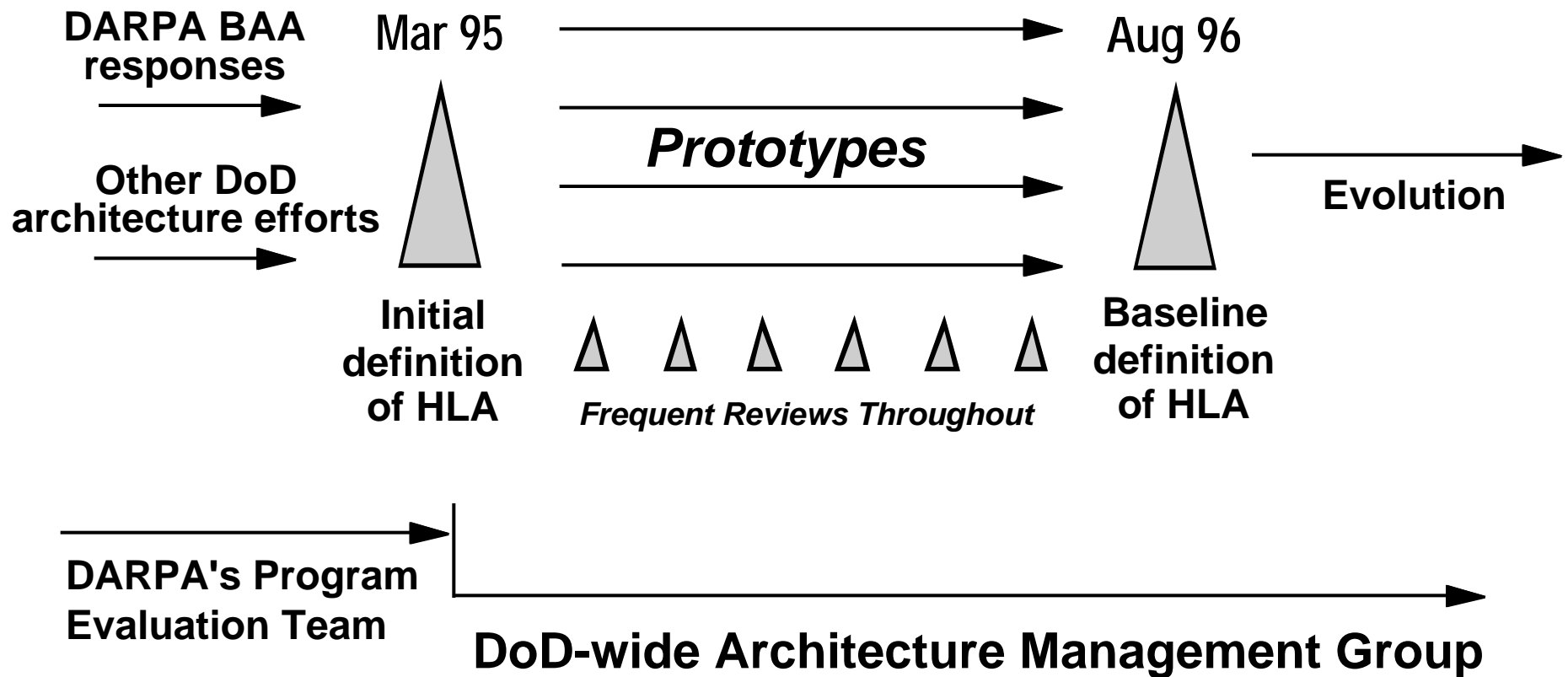


# Role of HLA

- **Used by simulation system developers and policy makers**
- **Provides systematic and consistent basis for addressing simulation system design and implementation issues**
  - **Many difficult issues still need to be resolved at system level**
    - e.g., mechanisms for scalability, aggregation-disaggregation
- **Facilitates interoperability and reuse through a set of commonly applicable rules**
- **Furnishes framework for making policy decisions (e.g., imposition of specific standards)**

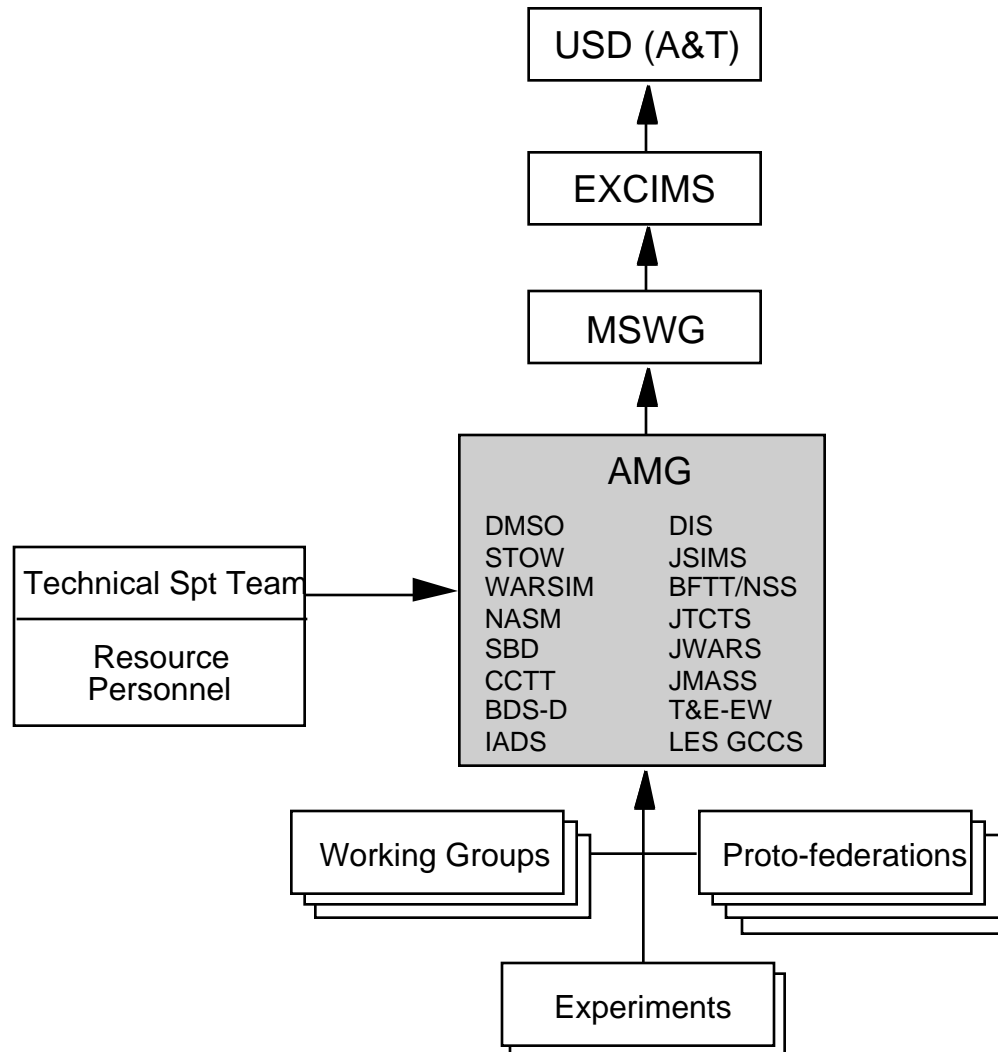


# High-Level Architecture Definition Process





# AMG Structure





# AMG Representatives

<u>Name</u>	<u>Representing</u>
CAPT Jim Hollenbach	Defense Modeling and Simulation Office
Dr. Judith Dahmann	Defense Modeling and Simulation Office TST
Mr. Dell Lunceford	Synthetic Theater of War
CAPT Drew Beasley	Joint Simulation System
Ms. Annette Ratzenberger	Wafighters' Simulation 2000
Dr. Les Parish	Battle Force Tactical Trainer/ Naval Simulation System
Mr. Tim Rudolph	National Air and Space [Warfare] Model
CAPT Bob Jacobs	Joint Tactical Combat Training System
Mr. Gary Jones	Simulation Based Design
COL Al Hammond	Close Combat Tactical Trainer
Dr. Jim Metzger	Joint Warfare System
LtCol Mike Cappelano	Joint Modeling and Simulation System
Mr. Rich Pace	Test & Evaluation/Electronic Warfare
Mr. Francis Cline	Integrated Air Defense Simulation
MAJ James Knowles	Leading Edge Services/Global Command and Control System
COL Michael Rogers	Battlefield Distributed Simulation-Developmental



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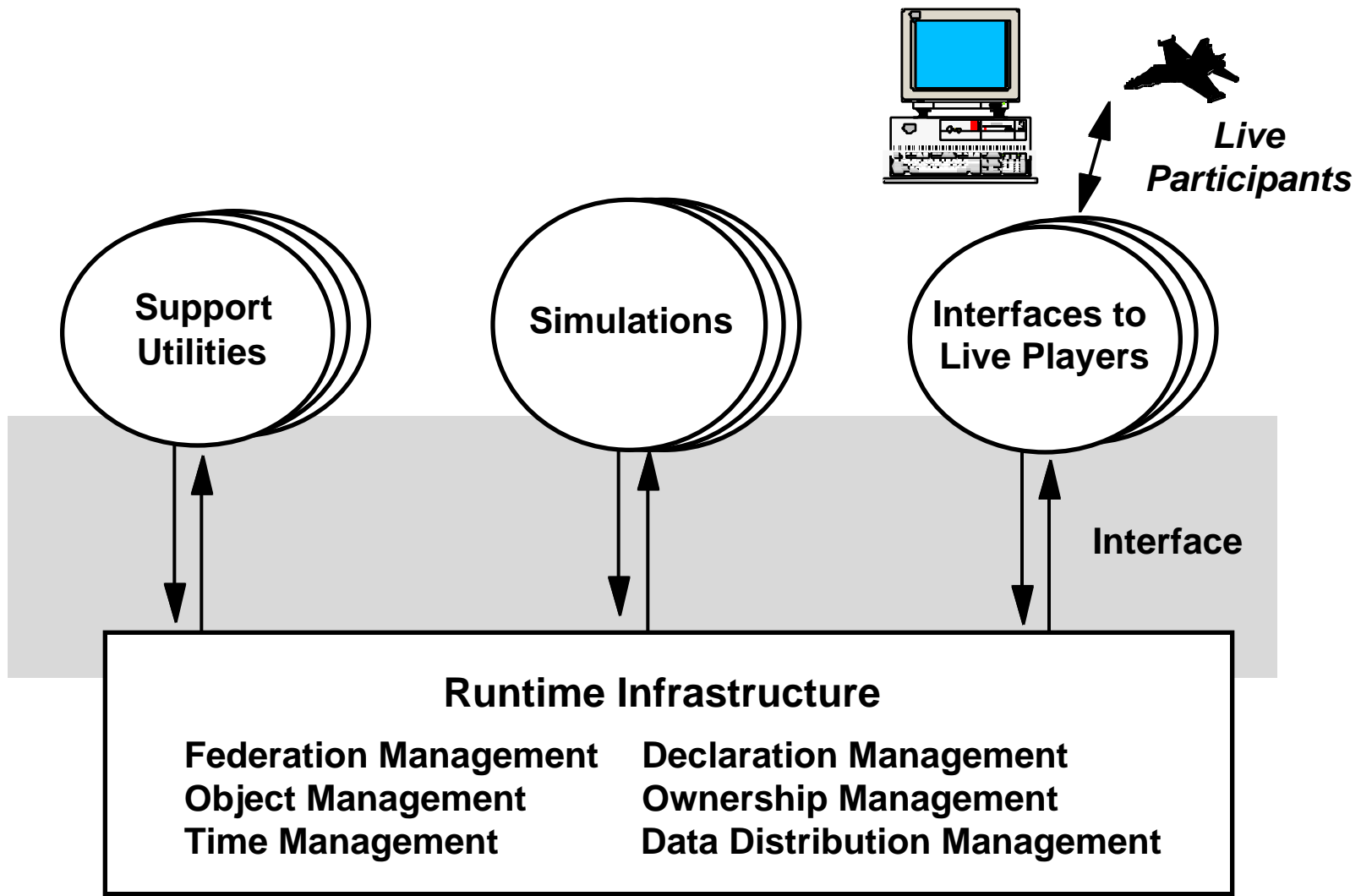


# Rationale for HLA Design

- ***Basic premises:***
  - No single, monolithic simulation can satisfy the needs of all users
  - All uses of simulations and useful ways of combining them cannot be anticipated in advance
  - Future technological capabilities and a variety of operating configurations must be accommodated
- ***Consequence:*** Need composable approach to constructing simulation federations
- ***Resulting design principles:***
  - Federations of simulations constructed from modular components with well-defined functionality and interfaces
  - Specific simulation functionality separated from general purpose supporting runtime infrastructure

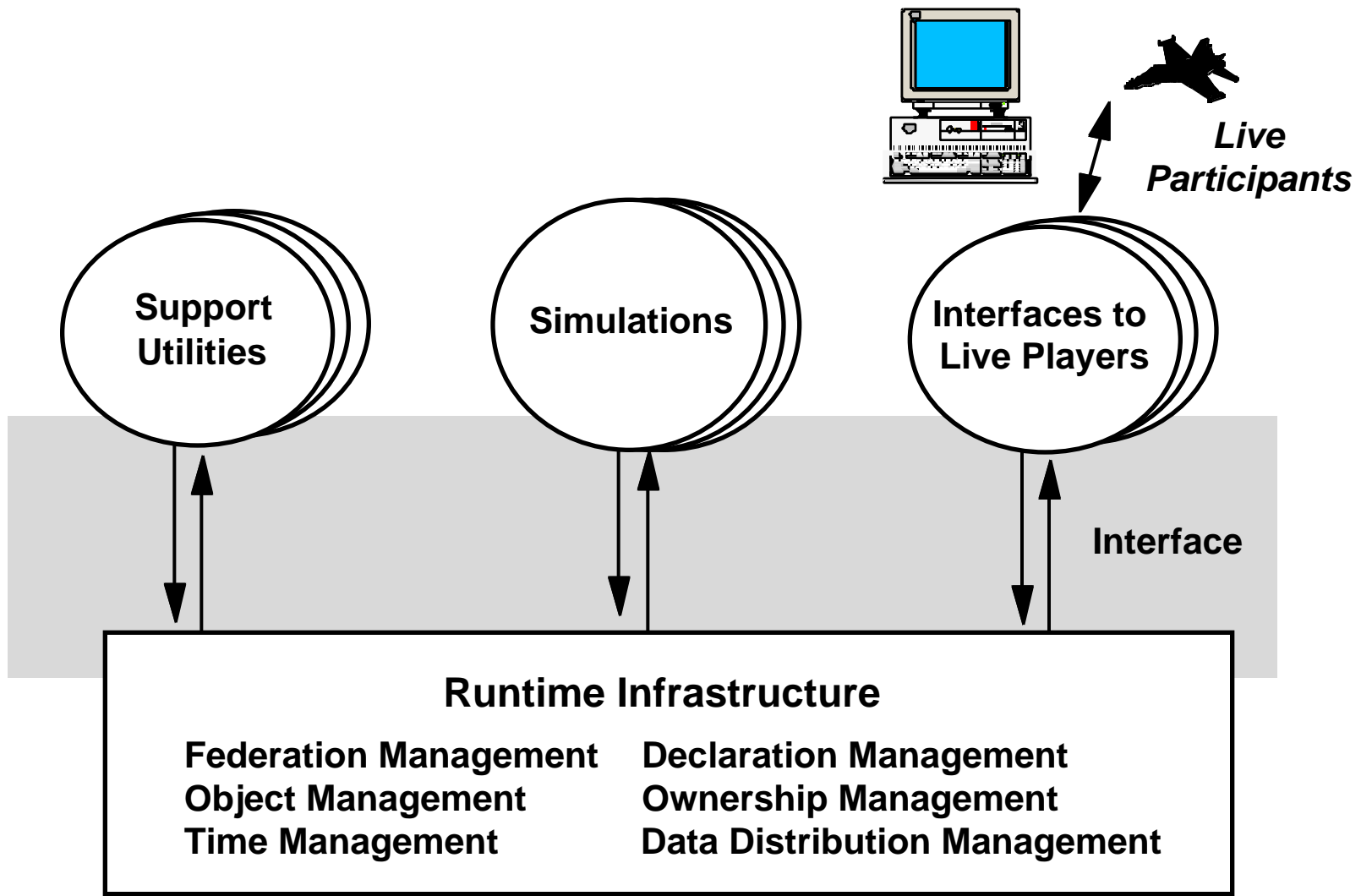


# Functional View of the Architecture





# Functional View of the Architecture





# Defining the HLA

- **HLA Rules.** A set of rules which must be followed to achieve proper interaction of federates during a federation execution. These describe the responsibilities of federates and of the runtime infrastructure in HLA federations
- **Interface Specification.** Definition of the interface services between the runtime infrastructure and the federates subject to the HLA
- **Object Model Template.** The prescribed common method for recording the information contained in the required HLA Object Model for each federation and federate



# Federation Rules

- 1 Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT).**
- 2 In a federation, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI).**
- 3 During a federation execution, all exchange of FOM data among federates shall occur via the RTI.**
- 4 During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification.**
- 5 During a federation execution, an attribute of an instance of an object shall be owned by only one federate at any given time.**



# Federate Rules

- 6 Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT).**
- 7 Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM.**
- 8 Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM.**
- 9 Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM.**
- 10 Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation.**

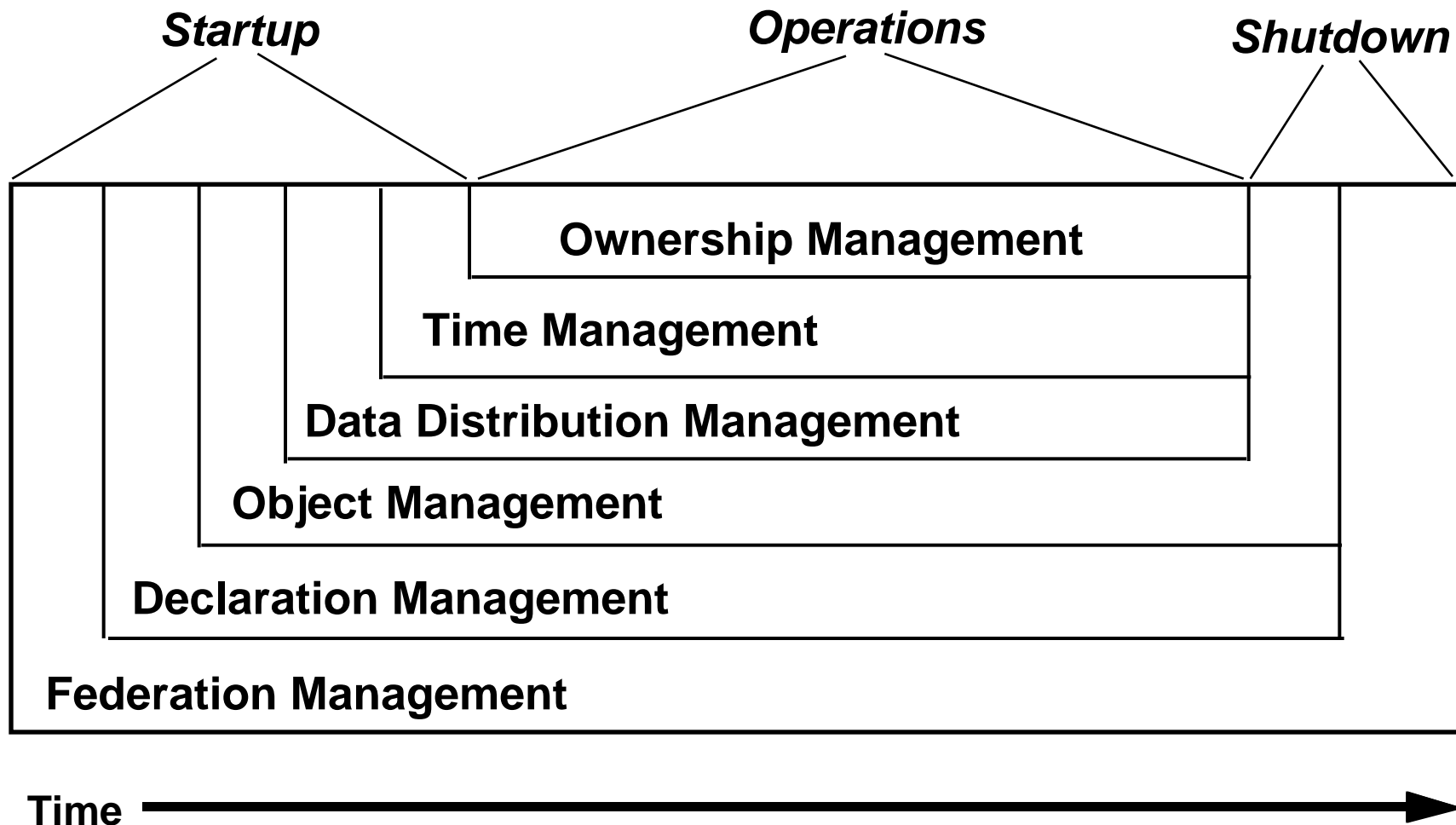


# HLA Interface Specification

Category	Functionality
Federation Management	Create and delete federation executions Join and resign federation executions Control checkpoint, pause, resume, restart
Declaration Management	Establish intent to publish and subscribe to object attributes and interactions
Object Management	Create and delete object instances Control attribute and interaction publication Create and delete object reflections
Ownership Management	Transfer ownership of object attributes
Time Management	Coordinate the advance of logical time and its relationship to real time
Data Distribution Management	Supports efficient routing of data



# HLA RTI Services over the Life of a Federation





# Rationale for Object View

- **Provides a convenient way to describe the real world**
- **Facilitates communication between simulation users and developers**
- **Promotes common understanding of real-world representations within and between simulations**
- **Caveat: Use of object view implies nothing about implementation means (e.g., use of object-oriented programming languages)**



# HLA Object View

- Real-world entities of interest for a simulation are regarded as objects
- Objects have three basic characteristics:
  - *Identity* – Those features (e.g., name) that distinguish one object from all others
  - *State* – The composite of all the static and dynamic properties of an object at any instant in time
  - *Behavior* – How an object acts and reacts in terms of its state changes
- The relationship of objects to one another is specified through:
  - *Attributes* – Those state variables and other parameters of an object that can be accessible to other objects
  - *Association* – The conceptual connection between objects (e.g., one object is part of a larger object)
  - *Interaction* – The influence of one object's state on the state of another object



# HLA Object Models

- **Object models describe:**
  - The set of shared objects chosen to represent the real world for a planned simulation or a federation
  - The attributes, associations, and interactions of these objects
  - The level of detail at which these objects represent the real world, including spatial and temporal resolution
  - The key models and algorithms used in representing the objects
- **The HLA will provide a template to characterize the object models**
  - Object Model Template (OMT) specification

**Note:** The term object model here should not be identified with the term used in some texts on object-oriented analysis and design methodologies. The term is used more generally here.



# HLA Object Models and Object Model Template

- **Object Model Template (OMT)**
  - Provides a common framework for HLA object model documentation
  - Fosters interoperability and reuse of simulations and simulation components via the specification of a common representational framework
- **Federation Object Model (FOM)**
  - A description of all shared information (objects, attributes, associations, and interactions) essential to a particular federation
- **Simulation Object Model (SOM)**
  - Describes objects, attributes and interactions in a particular simulation which *can* be used externally in a federation



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# Key Technical Issue Areas

- **Interface Specification:** *Technical feasibility of single interface for range of simulations and support functions*
- **Runtime Infrastructure:** *Technical feasibility, reusability, portability, and variability of RTI*
- **Simulations:** *Impact of HLA on simulations*
- **Object Models:** *Usability, functionality over life cycle, presentation approaches*
- **Testing:** *Test methods for HLA and Federations*
- **Security:** *Security Implications of the HLA*
- **Scope:** *Breadth of HLA applicability including C4I Interfaces*

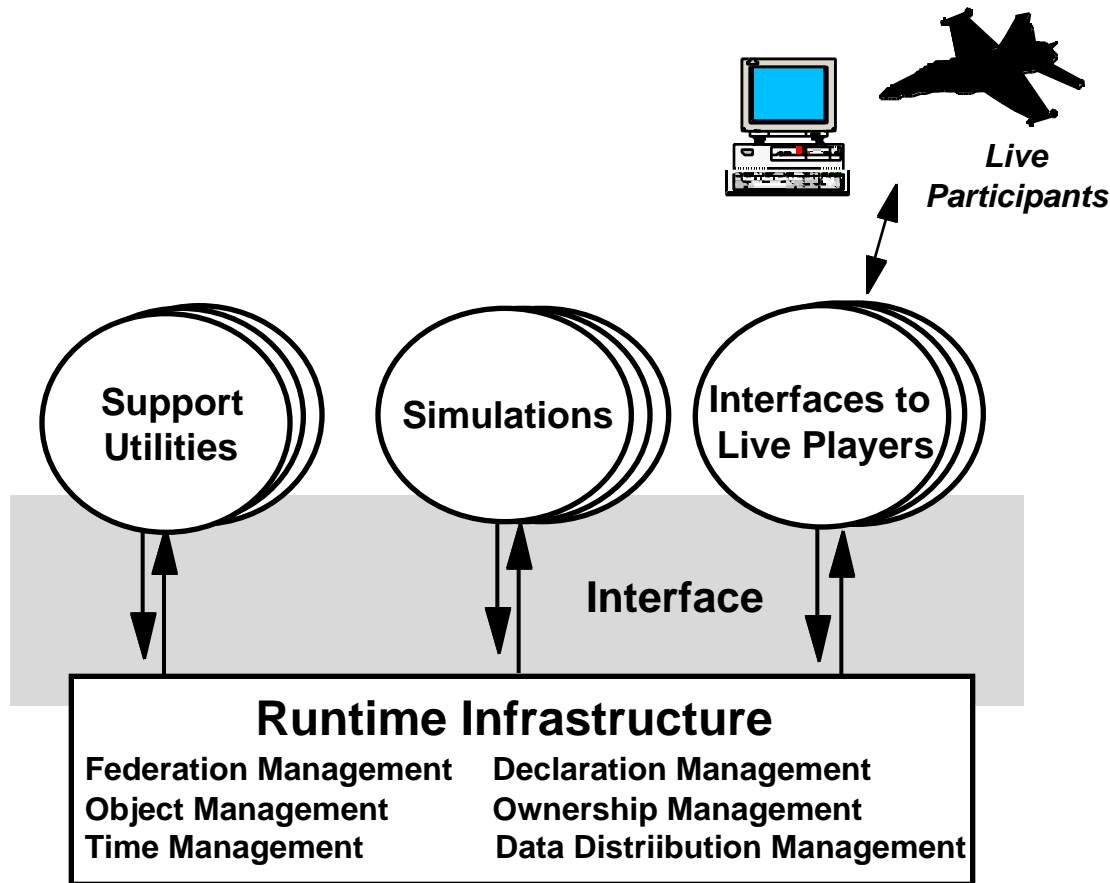


# HLA Prototype Federations

- **Five prototype federations**
  - **Platform Proto-federation**
  - **Joint Training Proto-federation (JTFp)**
  - **Analysis Proto-federation**
  - **Engineering Proto-federation**
  - **Joint Precision Strike Demonstration (JPSD) Experiment**



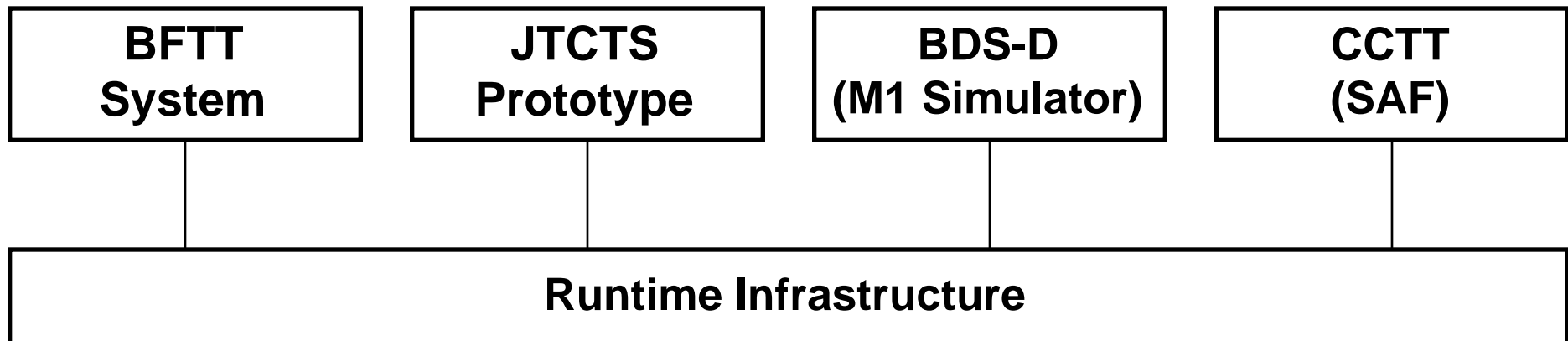
# The Prototype Runtime Infrastructure (RTI)



- Distributed operating system-like services to support federation runtime operations
- RTI prototype will support multiple proto-federations
- Phased development



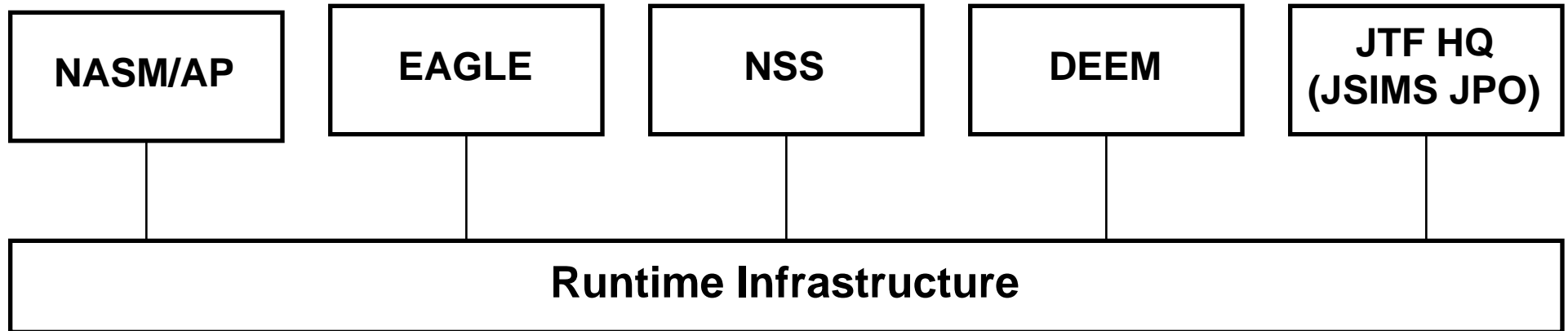
# The Platform Proto-federation



- Platform level real time simulators/simulations
- Currently use DIS 2.X
- Key issues
  - performance
  - transition from DIS to HLA implementation



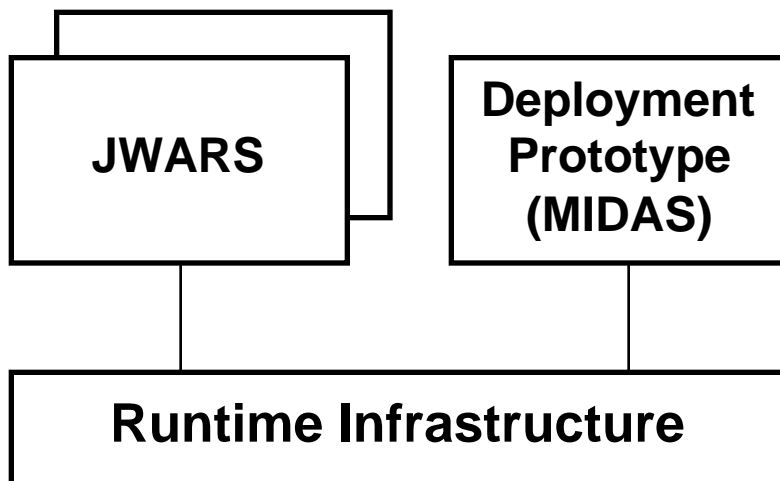
# The Joint Training Proto-federation



- **Distributed discrete event simulations**
- **Key issues:**
  - **Time management**
  - **Object ownership**
  - **Environmental representation**



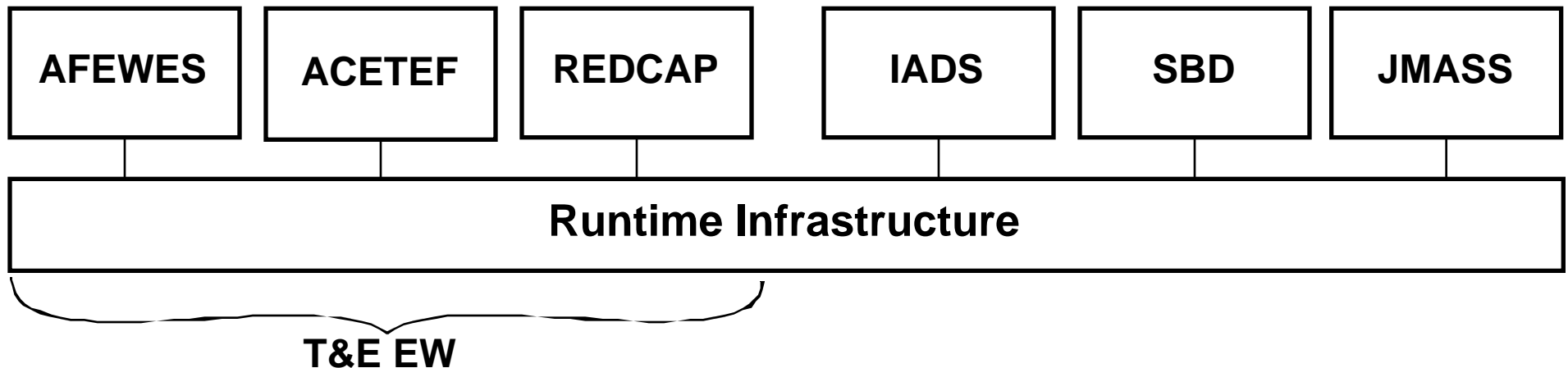
# The Analysis Proto-federation



- **Faster than real time, closed form analysis simulation**
- **Key Issues:**
  - Time management
  - Data filtering
  - Replicability
  - Runtime efficiency



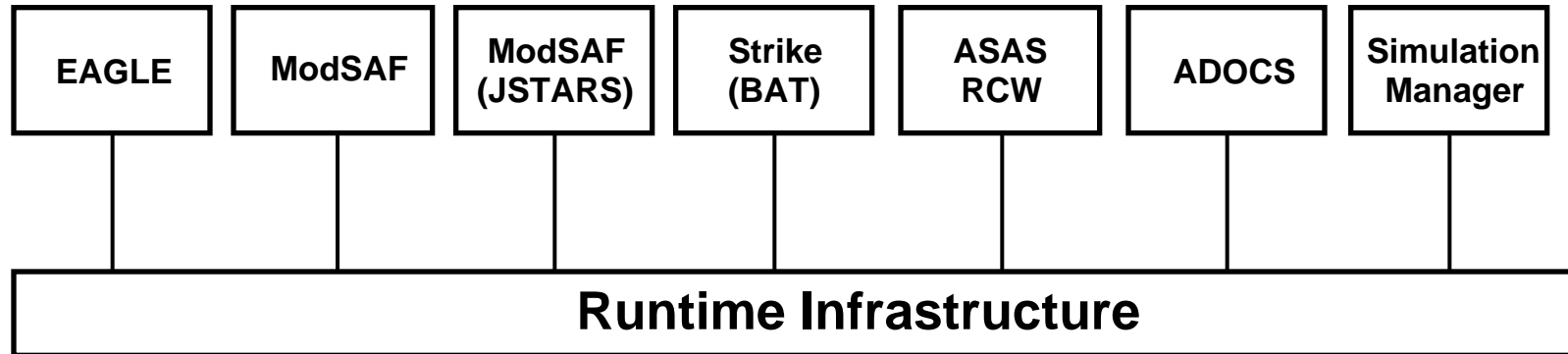
# The Engineering Proto-federation



- **Networked Engineering-level simulation capabilities**
  - Validated detailed, high fidelity simulations
  - DoD 5000 series-compliant acquisition support for T&E and concept evaluation
- **Key Issues:**
  - Object ownership management
  - Performance



# The Joint Precision Strike Demonstration (JPSD) HLA Experiment



- **Heterogeneous mix of federates in an existing experimental simulation environment**
- **Current implementation augments DIS 2.X with tailored HLA-like functionality**
- **Key issues**
  - **Can HLA support current functionality?**  
(declaration management, object ownership management, performance)

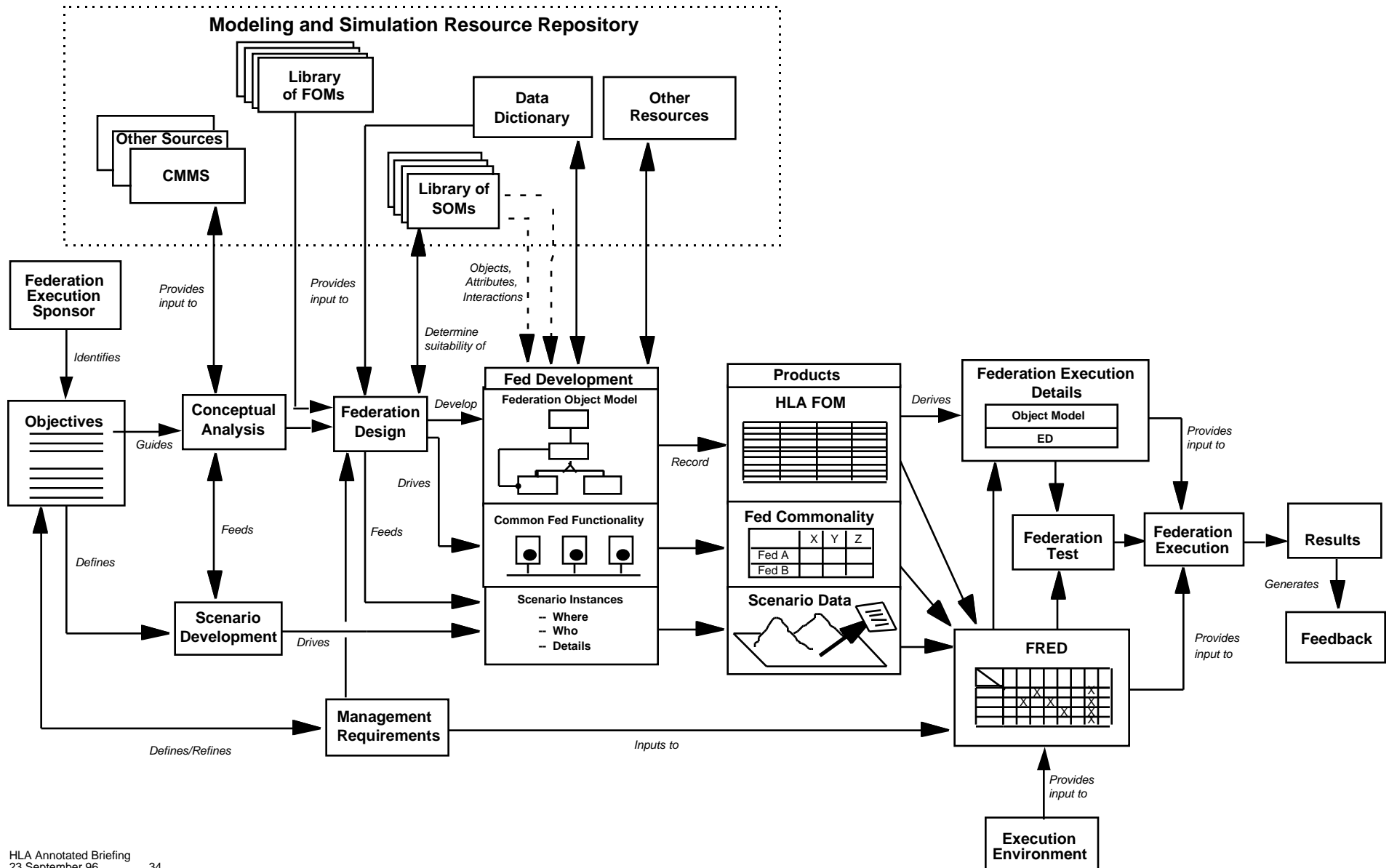


# Proto-federations and HLA Baseline Definition

- **Proto-federation experiences support HLA baseline definition**
  - **HLA Specifications: Feedback in Interface Specification, Object Model Template, and test procedures (through AMG working groups)**
  - **Lessons Learned for Transition: Profiles of federate adaptation to capture implementation experience**
  - **Process of Use: Generating a Federation Development and Execution Process based on composite experience**



# Federation Development and Execution Process





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- **Interoperability and Reuse**
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# Interoperability

***“M&S Interoperability – The ability of a [...] simulation to provide services to, and accept services from, other [...] simulations, and to use the services so exchanged to enable them to operate effectively together.”***

**– DoDD 5000.59**



# HLA and Interoperability

- **Interoperability requires the ability both to exchange data and to interpret it consistently**
- **HLA-required functionality and interfaces provide ability to exchange data**
  - **Provides mechanism to establish federation of simulations, transfer object data among simulations, and coordinate simulation operations**
- **HLA-required federation object models facilitate consistent interpretation of exchanged data**
  - **Provide information on objects, their public attributes, associations, interactions, level of resolution, and key models and algorithms used in their representation**



# Realization of Interoperability

- **Interoperability is a matter of degree, depending on the needs of each community of common interest**
- **Universal interoperability would require a universal object model (an unrealizable ideal)**
  - **Extent of functional communities too large to capture their diverse needs in one object model**
  - **Different simulation purposes require different levels of abstraction**
- **Reuse and portability are different than interoperability**

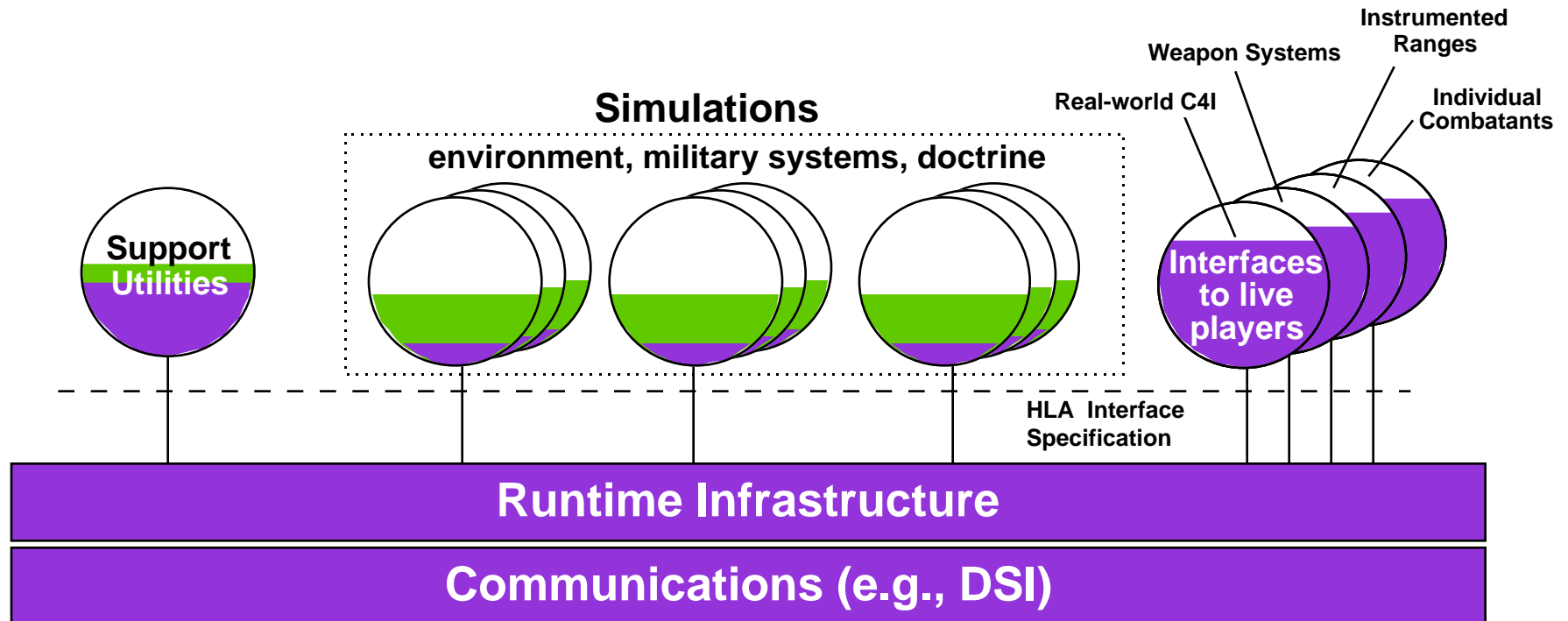





# Degrees of Interoperability

- **HLA-required functionality, interfaces, and object models provide a baseline level of interoperability**
- **Additional degrees of consistency could be required for satisfactory interoperability – e.g.:**
  - **Agreement regarding non-public objects and attributes**
  - **Publication of information on models and algorithms beyond that required by HLA**
  - **Sharing of models/algorithms and parameter values**
  - **Sharing of executable simulation components**
- **Required degree of interoperability beyond that provided by HLA is a policy matter for each community of common interest**
  - **Has implications for development time, cost, and flexibility of simulation use**



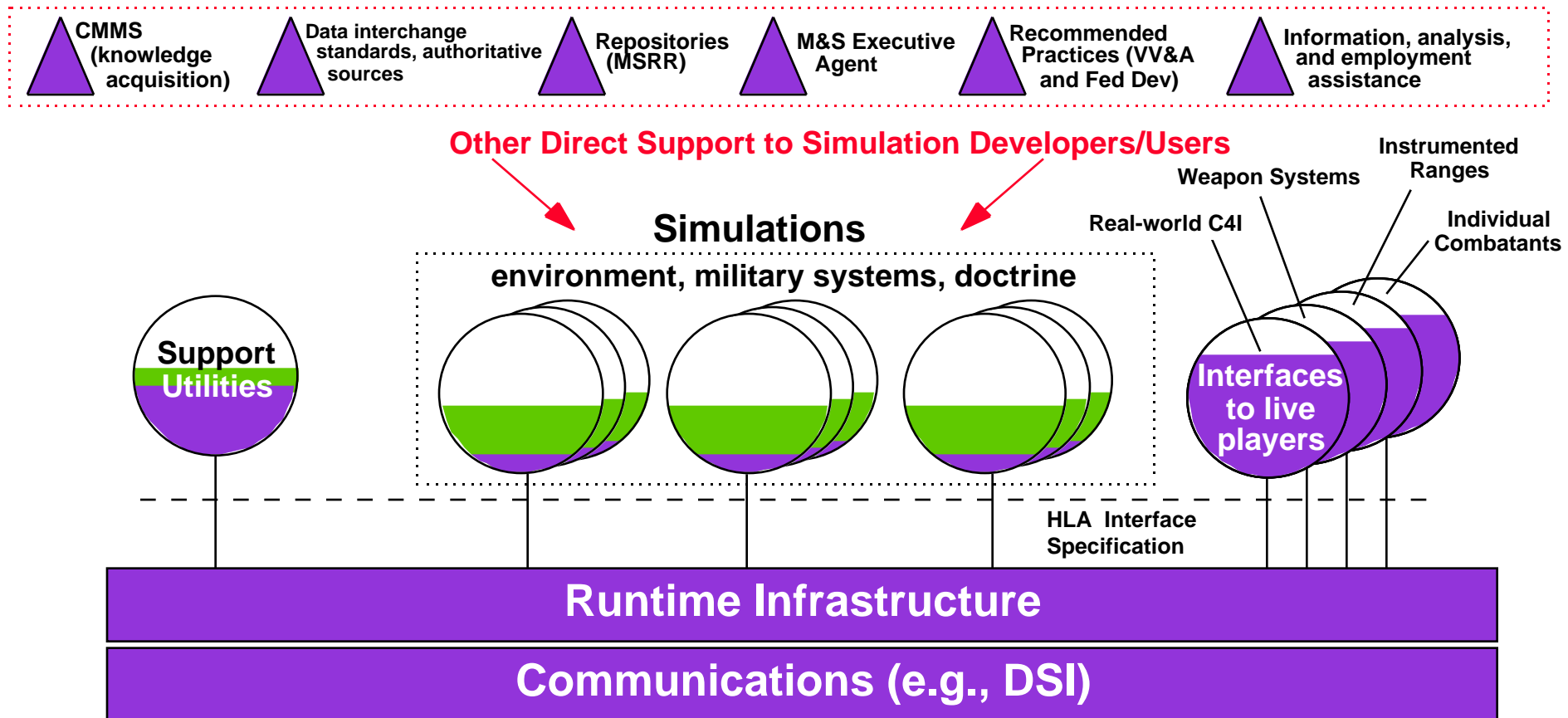
# Opportunities for Reuse



- Key:**
-  Reusable across all DoD simulation systems
  -  Reusable across a simulation domain
  -  unique



# Opportunities for Reuse (con't)



Key: Reusable across all DoD simulation systems  
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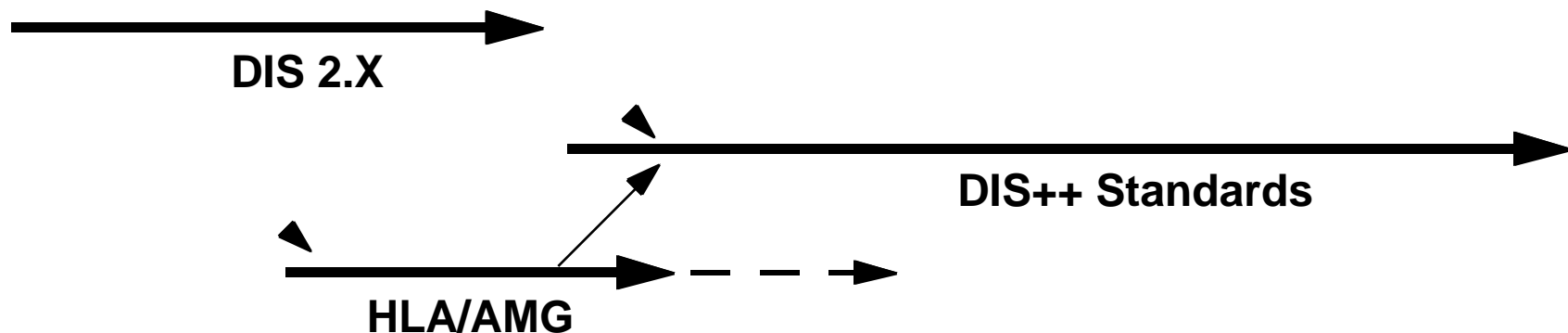
# HLA Compliance

- **HLA compliance checklist has been developed**
- **Testing Working Group has defined testing procedures for the interface specification and the OMT. These guide HLA compliance testing.**
- **By 2Q FY97, all on-going DoD simulation programs must be reviewed for feasibility of immediate HLA compliance**
  - identify date for compliance; or
  - report to DDR&E the reasons HLA is not acceptable
- **Goal is to lead with a carrot, not a stick**
  - save PMs cost, schedule, risk
  - have readily available supporting software
  - facilitate interoperability and utility of their sims



# HLA Supporting Standards

- **Important that HLA be integrated into broader, industry based technical community**
  - Many HLA concepts/goals were birthed within DIS workshop
  - HLA development supports achievement of the DIS Vision
  - DIS players are deeply involved in HLA development
  - DIS Workshop is the desired venue for establishment of HLA supporting standards.





# HLA Technical Library

- **DMSO has established an online “public library” for the M&S community, available through the DMSO Web page**
- **Contents**
  - **HLA Baseline Definition (Rules, Interface Specification, Object Model Template)**
  - **HLA Glossary**
  - **Interface Specification Supporting Documents (Test Procedures, Time Management, API)**
  - **OMT Supporting Documents (OMT Extensions, Test Procedures)**
  - **HLA Compliance Checklist**
  - **HLA Federation Development Process Model**
  - **HLA Security Architecture**
  - **Additional briefings and documents**



# On-Line Documentation

- Proceedings and products of the AMG appear under the subtopic “Common Technical Framework for M&S”, under “High Level Architecture”. DMSO home page site is:

**<http://www.dmsso.mil/>**

- Specific questions can be directly addressed to DMSO via electronic mail at

**[hla@msis.dmsso.mil](mailto:hla@msis.dmsso.mil)**